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Phenophase Prediction Model for Safflower

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Abstract

Field experiments were conducted during 2017-18 and 2018-19 on clay loam soils at research farm of Dry Farming Research Station, Solapur, to study the influence of sowing time on phenology and growth of the safflower cultivars and to develop the phenophases prediction model based on the agro meteorological indices. The treatment consisted of three dates of sowing and two cultivars of safflower. The results showed that the safflower sown under early sown condition, safflower crop took more thermal time as compared to normal and late sown. The day length and bright sunshine hours also affected the occurrence of different phenophases of safflower cultivars, Accumulated thermal time (r=0.94) was best agro meteorological indices for prediction of flowering stage in safflower, while physiological maturity was predicted well by using helio thermal unit (HTU) (r=0.95). The heat use efficiency decreased with delay in sowing. The dry matter production (g/m2) was linearly related with accumulated heat units, HTU and photo thermal indices .

Key words : Safflower, phenophases, cumulative heat unit, heliothermal unit, photothermal unit.

Safflower (*Carthamus tinctorius* L.) is one of the worlds' oldest crop Climatic conditions of Maharashtra are favorable for safflower cultivation. The weather conditions that prevail during crop growth period decides yield potential, even though all inputs required by the crop are supplied at the optimum level. A change in the optimum temperature during its vegetative or reproductive growth adversely affects the initiation and duration of different phenophases and finally yields of the crop. It is therefore, essential to have knowledge of exact duration of development phases in a particular environment and their association with yield determinants for achieving high yields (Kumari *et al*., 2009). The concept of growing degree days is based on the concept that real time to attain a phonological stage is linearly related to temperature in the range between base temperature and optimum temperature (Monteith, 1981). HUE i.e. efficiency of heat in terms of dry matter accumulation is an important aspect, which has great practical application. Efficiency of conversion of heat energy into dry matter depends upon genetic factors, sowing time and crop type (Rao *et al*., 1999).

It was observed that sunshine hours, day length, rainfall, mean temperature played a major role on the occurrence of emergence, rossete termination, branch initiation, bud initiation, flower initiation, 50% flowering, cessation of flowering and physiological maturity stages in Scarcity region of Maharashtra sown under different environments.

Materials and methods

Field experiments were conducted at Research farm of Dry Farming Research Station, Solapur, Maharashtra during 2017-18 and 2018-19. It is situated at 17°41N latitude, 75°-45E longitude at an altitude of 476 meters

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above sea level. The treatments consist of three dates of sowing *viz.*; 1st fortnight of September (D_1), 2nd fortnight of September, (D_2) and 1st fortnight of October (D_3) with two cultivars of safflower *viz.*, Bhima (V_1) Phule Kusuma (V_2). The treatments were replicated thrice in split plot design with dates of sowing in main plots and genotypes of safflower in subplots. Crop was raised using appropriate package of practices. Observations on different phonological stages such as Emergence, Rossete termination, Branch initiation, Bud initiation, Flower initiation, 50% Flowering, Cessation of flowering and physiological maturity stages were recorded for every treatment by tagging five plants. The weather data were recorded at Agromet Observatory situated at 200 m away from the experimental area. With the help of this meteorological data following agro meteorological indices *viz.*, Growing degree days (GDD),Photothermal units (PTU), Helio thermal units (HTU) were calculated at different stages (Nottonson, 1955). The heat use efficiency (HUE) was calculated as: HUE = Dry matter (kg ha^{-1}) / Cumulative heat unit (C days)

Results and discussion

Growing degree days (GDD) : The thermal times accumulated for attaining different phenophases are presented in Table 1. The safflower crop took 1293 degree days for maturation with a standard deviation of 68 days. The early sown crop required more thermal time in comparison with normal and late sown crop and it might be due to increase in mean temperature which shortened later stages of safflower crop. Similar type of results were found by Agrawal and Upadyay (2009), Singh *et al*. (2003), Mallicck *et al*. (1981). The safflower crop after flowering took maximum thermal time for attaining cessation stage among various dates of sowing as well as by different cultivars. Among cultivars Phule Kusuma took higher thermal time for maturity as compared to other cultivars.

Heat use efficiency : Heat use efficiency was computed to determine the biomass production per unit of growing degree-day for different safflower cultivars. The heat use efficiency increases with the advancement of the crop age up to flowering stage except the early sowing thereafter it decrease due to leaf senescence and biomass accumulation more in grains as compared to other parts of the plant. The heat use efficiency decreased with delay in

Table 1. Cumulative thermal times (day °C) acquired to attain different phenophases in safflower under different treatments (mean of two years)

Treatments	Emergence	Rossete termination	Branch initiation	Bud initiation	Flower initiation	50% flowering	Cessation of flowering	Phy. Mat
Sowing dates								
1st fortnight of September (D_1)	82.8	373.6	451.5	579.8	670.3	1003.8	1190.4	1346.3
2nd fortnight of September (D_2)	70.5	255.8	345.6	525.3	625.2	936.7	1157.9	1317.3
1st fortnight of October (D_3)	85.8	191.5	330.8	531.5	587.0	894.7	1060.4	1215.5
Mean	79.7	273.6	376.0	545.5	627.5	945.0	1136.2	1293.0
SD±	8.1	92.3	65.8	29.8	41.7	55.0	67.7	68.7
Cultivars								
Bhima	79.7	270.4	357.3	541.5	606.9	940.5	1125.2	1285.3
Phule Kusuma	79.7	280.1	424.1	565.9	665.5	972.8	1160.7	1318.9
Mean	79.7	273.6	376.0	545.5	627.5	945.0	1136.2	1293.0
SD±	0.0	4.9	37.6	14.0	31.2	17.8	17.2	13.7

sowing (Kumari *et al*. 2009. Hundal *et al.*, 2004). The early sown had higher HUE as compared to normal and late sown safflower crop due to higher biomass production (Table 2). The mean HUE were 9.5, 8.2 and 8.1 kg ha^{-1} °C day^{-1} by safflower sown early, normal and late, respectively to attained the physiological maturity. The maximum HUE was found in early sown safflower crop at 50% Flowering and Cessation of flowering compared to normal and late sown.

The heat use efficiency among various cultivars also increased with the advancement of crop growth stage upto Cessation of flowering and decreased thereafter up to physisological maturity due to leaf senescence. Among all the treatments the cultivar Phule-Kusuma has found maximum HUE (11.2 kg ha^{-1} °C-1 day^{-1}).

Phenophases prediction models based on GDD, HTU and PTU : Simple linear models were developed between number of days and agro meteorological indices in order to know the occurrence of different growth phenophases and find out the best indices for prediction of particular stage. The regression analyses showed that Emergence, Rossete termination, Branch initiation, Bud initiation, Flower initiation, 50% Flowering , were better related with thermal time as compared to helio thermal units and photo thermal units. Whereas, Cessation of flowering and physiological maturity stage could be predicted better with

Table 2. Effect of sowing dates on Heat Use Efficiency (kg ha^{-1} day^{-1} °C) in safflower cultivars sown under Scarcity region (mean of the two years)

Treatments	Rossete termination	Branch initiation	Bud initiation	50% flowering	Cessation of flowering	Maturity	Mean
Sowing dates							
1st fortnight of September (D_1)	2.8	9.7	9.4	11.8	11.8	11.3	9.5
2nd fortnight of September (D_2)	3.3	7.7	10.2	10.1	9.4	8.7	8.2
1st fortnight of October (D_3)	4.5	6.9	10.1	9.5	9.2	8.5	8.1
Mean	3.5	8.1	9.9	10.5	10.1	9.5	8.6
Cultivars							
Bhima	3.2	7.5	9.8	8.5	8.3	7.9	7.5
Phule Kusuma	3.8	8.8	10.5	11.2	10.9	9.9	9.2
Mean	3.5	8.1	9.9	10.5	10.2	9.5	8.6

Table 3. Phenophase prediction model based on different Agro meteorological in ices in safflower

Phenophase	Equation (GDD)	R^2	Equation (HTU)	R^2	Equation (PTU)	R^2
Emergence	Y=0.9263X+70.145	0.27	Y=3.0761X+522.4	0.04	Y=2.447X+831.44	0.02
Rossete termination	Y=-0.925X+444.68	0.22	Y=-19.986X+2880.6	0.70	Y=-25.66X+4323.2	0.62
Branch initiation	Y=3.0796X+97.294	0.54	Y=-8.9209X+2866.6	0.36	Y=-7.1685X+4609.8	0.12
Bud initiation	Y=14.223X-1785.6	0.81	Y=17.622X+666.72	0.29	Y=31.346X+1678.2	0.59
Flower initiation	Y=8.8545X-869.66	0.74	Y=99.299X-13909	0.80	Y=117.85X-12678	0.59
50% Flowering	Y=7.8736X-533.66	0.94	Y=66.809X-7684.1	0.67	Y=77.258X-5348.8	0.75
Cessation of flowering	Y=9.7998X-930.48	0.95	Y=55.178-4632.6	0.83	Y=57.218X+936.71	0.77
Phy. Mat	Y=6.7773X-192.52	0.97	Y=47.229X-2702.6	0.95	Y=80.099X-2498.3	0.81

accumulated helio thermal units with accuracy of 70, 80 and 95%, respectively (Kaur *et al*. 2009). The poor relationships were found with photo thermal units (Table 3).

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Trend Analysis of Annual Rainfall and Rainy Days Over Pune District of Maharashtra

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Abstract

Rainfall analysis would enhance the management and effective utilization of water resources. Analysis of trend is useful to examine the long term trends in rainfall and rainy days over. The present study has been undertaken in fourteen Tehsils of the Pune district to study rainfall and rainy days trend using Mann-Kendall Test and Sen's Slope method and GIS based maps are prepared. The annual rainfall trend over the most of tehsils has been increased with increasing rainy days while, rainfall trend in Ambegaon, Baramati tehsils decreased with increasing rainy days and in Junnar and Purandar tehsils it was decreased with decreasing rainy days. Spatial variation in trends of annual rainfall showed in a map prepared in the GIS environment.

Key words : Rainfall, Rainy days trend, Mann-Kendall Test, Sen's Slope method, GIS.

The Indian monsoon is highly erratic both in quantum as well as distribution. The monsoon characteristics relating to its time of onset, withdrawal and distribution control agricultural production and in turn the livelihood of the people. In India, rainfall received from southwest monsoon (June to September) is a major source of water for agriculture. However, it is most

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